



Department of Energy
Germantown, MD 20874-1290

Safety Evaluation Report

**Conservative Alternative Approach to Demonstrate Criticality Safety
for FERMCO Primary Ingots, FERMCO Derbies, and Hanford RMI Billets - Mark I
Outer in the Rev. L SARP of the Steel Banded Wooden Shipping Containers (SBWSC)**

Docket No. 00-25-5467

Background

This Safety Evaluation Report (SER) addresses a conservative alternative approach in the criticality confirmatory evaluation of three types of payload - FERMCO Primary Ingots, FERMCO Derbies, and Hanford RMI Billets - described in the Rev. L SARP for the Steel Banded Wooden Shipping Containers (SBWSC). The U-235 enrichment, the outer diameters (OD), inner diameters (ID), and ingot lengths (L) are given in Table 1.2.3-1 of the Rev. L SARP and Tables 1 to 3 of this SER. The revisions (K and L) of the SARP were necessary due to an increase in the maximum U-235 enrichment in the payloads from 0.95-1.25 to 0.956-1.256 wt.%.

Conservative Alternative Approach in Confirmatory Evaluation

The staff reviewed the criticality analysis results for the selected payloads in the Rev. L SARP. Due to the relatively high values of the adjusted effective neutron multiplication factor, k_{adj} (>0.94) and the small margin to the subcriticality safety criterion of 0.95, at the request of the Headquarters Certifying Official, the staff proposed to reduce the maximum subcritical mass of each payload by 25% in order to ensure criticality safety and expedite the criticality confirmatory evaluation. The staff has confirmed that the Transport Index (TI) and the maximum number of packages for the selected payloads in an exclusive use shipment, adjusted for a reduction in payload mass of 25%, meet the 10 CFR Part 71 criticality safety requirements for normal conditions of transport (NCT) and hypothetical accidents conditions (HAC).

Other safety aspects (i.e., general information, structural, thermal, shielding, containment, operating procedures, acceptance tests and maintenance, and quality assurance) of the SBWSC have been reviewed for similar types of payloads in Rev. G and J of the SARP and documented in the SERs for Rev. 11 and Rev. 12 of the Certificate of Compliance (CoC) dated July 15, 1999 and May 2, 2000, respectively. The conclusions obtained in the earlier evaluation and SERs for the other safety aspects of the SBWSC remain valid and applicable to the payloads evaluated in this SER and will not be repeated.



Reduction in Maximum Subcritical Mass

Table 1 lists the maximum subcritical mass of the selected payloads in the Rev. L SARP and the corresponding reduced mass in this SER. Although not listed in Table 1, the 25% reduction in the maximum subcritical mass is equivalent to $\approx 33\%$ increase in the TI calculated for each payload based on its maximum subcritical mass.

Table 1. Maximum Subcritical Mass for Selected Payloads in the Rev. L SARP and Reduced Mass in the SER

Payload	Type	Maximum Subcritical Mass in Rev. L SARP (kg)	Reduced Subcritical Mass in SER (kg)
FERMCO Primary Ingots	12-in OD x 17-in L	8430	6324
	12-in OD x 26-in L	8430	6324
	13-in OD x 30-in L	12144	9110
	9-in OD x 30-in L	13067	9803
FERMCO Derbies	12-in OD x 5-in L	8430	6324
Hanford RMI Billets Mark I Outer	6.98-in OD x 2.80-in ID x 18 to 19-in L	2933	2200
		2933	2200
		2933	2200

Criticality Confirmatory Evaluation

Table 2 lists the k_{adj} values calculated for the selected payloads in the Rev. L SARP and the reduced mass of each payload given in Table 1 of this SER. The 25% reduction in the maximum subcritical mass of each payload resulted in a k_{adj} value less than 0.93 and increased the margin for subcriticality safety. The increased margin to safety is judged acceptable and sufficient to bound the uncertainties resulting from the increased U-235 enrichment (from 1.25 to 1.256 wt.%) in the payloads without performing explicit criticality confirmatory analysis.

Table 2. k_{adj} Values for Selected Payloads in the Rev. L SARP
and Reduced Mass in the SER

Payload	Description	With Subcritical Mass in Rev. L SARP		With Reduced Subcritical Mass in SER	
		^{235}U , wt%	k_{adj}	^{235}U , wt%	k_{adj}
FERMCO Primary Ingots	12-in OD x 17-in L	1.256	0.9432	1.256	0.92713
	12-in OD x 26-in L	1.256	0.9432	1.256	0.92713
	13-in OD x 30-in L	1.256	0.9385	1.256	0.92732
	9-in OD x 30-in L	1.256	0.9398	1.256	0.92732
FERMCO Derbies	12-in OD x 5-in L	1.256	0.9432	1.256	0.92713
Hanford RMI Billets Mark I Outer	6.98-in OD x 2.80-in ID x 18 to 19-in L	1.256	0.9419	1.256	0.9204

Transport Index and Number of Packages per Shipment

The staff has determined the TI values for the evaluated payloads in Table 3 based on their reduced mass listed in Table 1 and subcriticality confirmed in Table 2.

Table 3. Transport Index (TI) Based on Reduced Subcritical Mass (RSM) for Selected payloads in the Rev. L SARP

Payload Piece	Size Piece	Mass of Piece, kg	Pieces/SBWSC	RSM, kg	SBWSC _(RSM) *	N**	TI***
FERMCO Primary Ingots	12-in OD x 17-in L	597.4	2	6324	5.293	2.647	18.9
	12-in OD x 26-in L	913.6	1	6324	6.922	3.461	14.5 ⁽¹⁾
	13-in OD x 30-in L	1237.2	1	9110	7.363	3.682	13.6
	9-in OD x 30-in L	593.0	2	9803	8.266	4.133	12.1
FERMCO Derbies	12-in OD x 5-in L	173.9	2	6324	18.18	9.091	5.5
Hanford RMI Billets, Mark 1 Outer	6.98-in OD x 2.80-in ID x 18 to 19-in L	189.5	1	2200	11.61	5.805	8.7
		189.5	2	2200	5.805	2.903	17.3
		189.5	3	2200	3.870	1.935	25.9

* Number of SBWSC containing the RSM calculated as follows:

$$SBWSC_{RSM} = (RSM) / \{ (Mass\ of\ Piece) (Pieces/SBWSC) \}$$

** $2N = SBWSC_{RSM}$

*** $TI = 50/N$

- (1) The value of the TI for the 12-in OD x 26-in L FERMCO Primary Ingots is corrected for an error as well as adjusted for the reduced mass. Starting with the SER that supports Revision 11 of the CoC (filed under dockets 96-39-5467, 98-20-5467, and 98-22-5467) and continuing in Revision 12, 13, and 14 of the CoC, the TI for a SBWSC with one of these Ingots is 21.4. A TI of 21.4 actually applies to a SBWSC containing two of these Ingots; with just one Ingot per SBWSC, the TI is 10.7. The TI of 21.4 is conservative relative to the true TI of 10.7

Summary

The staff has confirmed that the alternative approach based on 25% reduction of the maximum subcritical mass for the selected payloads (FERMCO Primary Ingots, FERMCO derbies, and Hanford RMI Billets) in the SBWSCs is indeed conservative. The staff has also established a new set of TIs that result in fewer packages per exclusive use shipment than those proposed in the Rev. L SARP. The new TIs meet the 10 CFR Part 71 criticality safety requirements for NCT and HAC.

A handwritten signature in black ink, reading "Michael E. Wangler". The signature is fluid and cursive, with the first name "Michael" and last name "Wangler" clearly distinguishable.

Michael E. Wangler, Director
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Office of Safety, Health and Security, EM-5

Date AUG 1 8 2000